

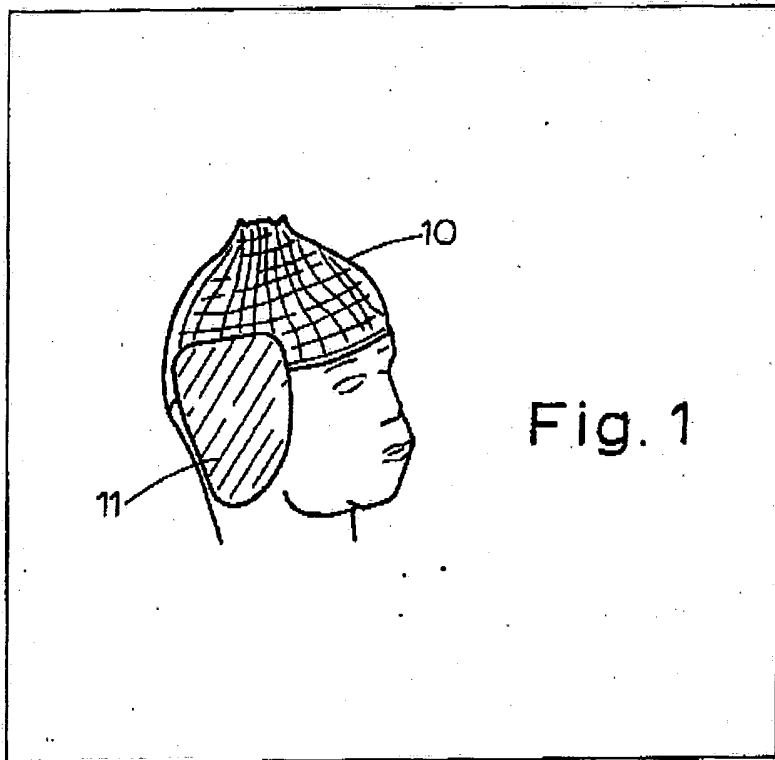
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## (54) Auditory testing device

(57) A device is provided for applying auditory stimuli to a new-born infant in order to test the infant's auditory acuity. The device includes a head-piece 10 formed from a length of generally tubular elasticated net bandage material. This may be stretched over the infant's head so as

to encircle the upper part thereof. Carriers 11, formed from laminated layers of foamed plastics material, are attached to the head-piece and each of them constitutes a flap which covers the infant's ear and holds an electro-acoustical transducer adjacent the ear. Sound is transmitted to the ear by air conduction, rather than by bone conduction.



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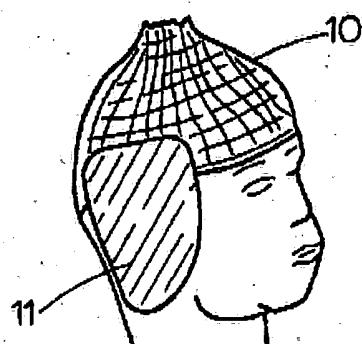


Fig. 1

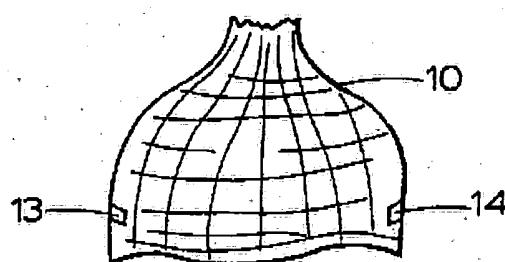


Fig. 2

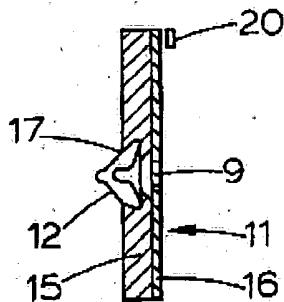


Fig. 3

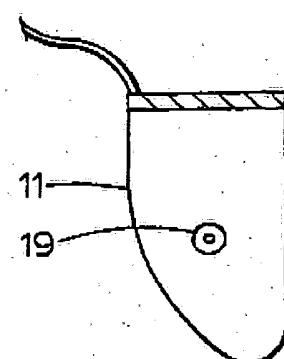


Fig. 4

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**SPECIFICATION**  
**Auditory testing device**

This invention relates to a device for applying auditory stimuli to subjects, and in particular to a device for applying auditory stimuli to new-born infants in order to test the infants' auditory acuity.

5 Sounds may reach a human ear by two routes, namely by air conduction and by bone conduction. The first route involves the hearing of sound waves set up in the air surrounding the ear by transmission of those waves along the auditory meatus and thence via the middle to the sensory inner ear. The second route involves the transmission of sound via the bone structure of 10 the skull directly to the inner ear, bypassing the auditory meatus. When a sound-emitter such as a loudspeaker is placed out of contact with a subject substantially all of the sound which is heard is received by air conduction. When a sound-producing device is placed in contact with a subject, particularly in contact with the head much of the sound is received by bone conduction.

15 It has been found that tests such as those referred to above can be carried out most satisfactorily only if the sound is received by a subject by air conduction.

20 Accordingly, the invention provides a device for applying auditory stimuli to a subject, comprising a head-piece adapted to be positioned on a subject's head, and a sound-emitter attached to the head-piece in such a way that, in use of the device, sound is transmitted to the subject by air conduction.

25 Preferably two emitters are used, each being positioned adjacent a respective ear, so as to allow the ears to be tested independently.

30 One way of achieving air conduction is to suspend the or each emitter from the head-piece so that it is spaced from the head of the subject. Alternatively, the or each emitter may be mounted 35 in a holder which is provided with a layer of material, such as a soft foam, which is substantially non-conductive as far as sound is concerned. That layer of material may then 40 contact the head of the subject without sound being transmitted thereto by bone conduction.

45 In testing the auditory acuity of a new-born infant it is convenient to apply an auditory stimulus to the infant while it is asleep or resting 50 passively. The use of conventional headphones or ear-pieces to apply the stimulus has the disadvantage that the act of fitting headphones or an ear-piece is likely to wake or otherwise disturb the infant and hence impede the observation of 55 the infant's response to the stimulus.

60 In a preferred embodiment of the present invention, therefore, at least part of the head-piece is formed of a resilient material which may be stretched over the subject's head so as to encircle the upper part thereof, and a carrier element is provided for holding an electro-acoustical transducer and which in use of the equipment provides a flap which covers the subject's ear and holds an electro-acoustical transducer adjacent

65 the ear. Separate carrier elements may be provided for locating a respective electro-acoustical transducer adjacent each of the subject's ears. Preferably the carrier elements are detachable 70 from the head-piece and attachment means are provided on the head-piece and/or on the or each carrier element to facilitate attachment of the carrier element or elements to the head-piece. Thus, for example, small eyelets or hooks may be 75 provided on either or both the head-piece and the carrier elements. Most preferably complementary attachment means are provided on the head piece and the carrier elements, for example attachment means of the kind comprising two types of pile-bearing fabric, the pile of one of the types of fabric being formed with a plurality of hooks and the pile of the other type of fabric being formed with a plurality of loops in which the hooks may be engaged. An example of this kind of attachment 80 means is that obtainable under the Trade Mark "Velcro". Preferably the attachment means are arranged so that the position of the carrier element or elements on the head-piece is adjustable.

85 90 The head-piece is preferably formed of a soft, light-weight material which is sufficiently thin and flexible to conform closely to the subject's head to provide a cap or bonnet-like covering. Thus, for example, the head-piece can conveniently be 95 formed from an elasticated net-like material such as the elasticated net bandage material obtainable under the Trade Mark "Netlast".

100 The carrier elements are preferably formed of flexible foamed material, for example foamed plastic or rubber and conveniently the carrier elements are in the form of a sheet of such material provided with an aperture in which the electro-acoustical transducer may be accommodated as an interference fit. Most 105 preferably the carrier elements are of a laminated construction formed of foams of different softness, with the softer foam being provided on the side of the carrier element intended to abut the subject's ear and the harder, less resilient foam being 110 provided with the aperture for accommodating the transducer.

115 A device according to the invention for use in testing infants' auditory acuity will now be described by way of example, with particular reference to the accompanying drawings of which:

120 Figure 1 is a schematic perspective view of a device according to the invention fitted to an infant's head;

125 Figure 2 is a front elevation of a first part of the device of Figure 1;

Figure 3 is a cross-sectional view of a second part of the device of Figure 1; and

Figure 4 is a side elevational view of the part shown in Figure 3.

130 Referring to the drawings, the device of Figure 1 comprises a head-piece 10, carrier elements 11 (of which only one is shown) and an electro-acoustical transducer in the form of a small ear-piece or loudspeaker 12.

Head-piece 10 is formed from a length of generally tubular elasticated net bandage material of the type sold under the Trade Mark "Natalast". In the drawings, the head-piece is shown in a distended condition as a result of having been stretched in order to fit over an infant's head. The head-piece may, of course, be made of material other than "Natalast", provided that it has sufficient elasticity to be retained comfortably on the infant's head. On diametrically opposed sides of the length of "Natalast" adjacent one end thereof are sewn or otherwise attached strips 13 and 14 of "Velcro".

Carrier elements 11 are formed from laminated layers 15 and 16 of foamed plastic material. Layer 15 is formed from harder material than layer 16 and is provided with an aperture 17 in which a small loud-speaker 12 is accommodated as an interference fit. The softer layer 16 is provided with an aperture 19 overlying the voice coil of the loud-speaker. Along one edge of each carrier element is attached a strip of "Velcro" 20 which is complementary to the strips 13 and 14 of the head-piece, thus enabling the carrier elements to be releasably secured to the head-piece. As can be seen from Figure 1, the carrier elements are of a size and shape such that when attached to the head-piece, they form flaps depending from the lower margin of the head-piece and over-lying the infant's ears, with the loud-speaker 12 located closely adjacent the ear.

Preferably, the "Velcro" strips are of a size and shape such that the position of the carrier elements 11 may be adjusted so as to ensure the loud-speakers 12 are correctly positioned.

Alternatively a series of "Velcro" strips or other attachment means may be provided at a series of positions on the head-piece and/or on the carrier elements to enable the carrier elements to be attached to the head-piece in the required manner by selecting a particular combination of attachment means resulting in the carrier elements locating the loud-speakers adjacent the infant's ears.

In use the equipment according to the invention, the head-piece 10 is stretched over the head of an infant whose auditory acuity is to be assessed, so as to assume a cap- or bonnet-like shape. The head-piece is oriented so that the "Velcro" strips lie on opposite sides of the head a short distance above the ears. By virtue of the elasticity, the head-piece is retained on and conforms closely to the shape of the infant's head. In view of its soft and comfortable nature, the head-piece is likely to be tolerated by the infant.

When the infant is asleep or resting, the carrier elements 11 with their associated loud-speakers are attached gently to the head-piece without disturbing the infant. Thereafter an auditory stimulus may be applied to the infant by feeding an appropriate electrical signal to the electro-acoustical transducers. The infant's auditory acuity may then be readily assessed by monitoring changes induced by the stimulus in the infant's

resting or sleeping state. Such changes may, for example be changes in pulse rate or respiration rate, the amount of body movement, or even the awakening of the child.

The device according to the invention may thus advantageously be used in conjunction with indicating and recording apparatus which simultaneously indicates and records both the output of the sound-emitter or emitters and the response of the subject as measured in terms of the state of various physiological functions of the subject (for example the pulse rate, the rate of respiration, and the amount of body movement) mentioned above. Conveniently, this can be done using an apparatus in which the output of the sound-emitter or emitters and the various physiological functions are recorded on parallel pen traces.

Although a variety of auditory stimuli might be used to assess an infant's auditory acuity using equipment according to the invention, particularly useful acoustic stimuli are sounds which correspond to those previously heard by the infant while still in the womb. Thus, for example, sounds corresponding to the so-called "combined uterus sound" may be transmitted through the loud-speakers from appropriate recording of an actual combined uterus sound or of a sound synthesised to imitate the actual combined uterus sound. These sounds generally cover a wide spectrum of sound frequency from high notes to low rumbling noises, but the dominant component has a frequency of about 200 Hz.

The equipment described above may be particularly advantageously used to apply an auditory stimulus consisting of sounds corresponding to the combined uterus sound to an infant, since the flap-like ear covering provided by carrier elements 11 enables the loud-speaker to be acoustically coupled to the infant's ears without exerting pressure thereon, thus enabling both the high and low frequency components of the combined uterus sounds to be transmitted to the infant's ears.

A further advantage of the equipment described is that the head-piece may be placed on the infant's head well before the testing of the auditory acuity is to begin. The carrier elements with the associated loud-speakers may then be applied subsequently without disturbing the child.

In one use of the invention the infant is subjected successively to the combined uterus sound, a sound corresponding to that by an infant, before birth, through the placenta and navel cord, and a high-pitched sound. The last sound serves to pick out infants suffering from jaundice. If the infant's hearing is correct there will be a change in its response with each transition from one sound to the next.

It may be convenient to provide a monitor whereby a person carrying out a test can hear the sound being delivered to the infant, and also observe a decibel metre which detects the level of sound being delivered.

## CLAIMS

1. A device for applying auditory stimuli to a subject, comprising a head-piece adapted to be positioned on a subject's head, and a sound-emitter attached to the head-piece in such a way that, in use of the device, sound is transmitted to the subject by air conduction.

5 2. A device as claimed in Claim 1 wherein the emitter is suspended adjacent the ear of the subject.

10 3. A device as claimed in Claim 1 wherein the emitter is mounted in a holder which is provided with a layer of material which is substantially non-conductive to sound.

15 4. A device as claimed in Claim 1 wherein at least part of the head-piece is formed of a resilient material which can be stretched over the subject's head so as to encircle the upper part thereof, and a carrier element is provided for holding the emitter adjacent to the subject's ear.

20 5. A device as claimed in Claim 4 wherein the carrier element is detachably mounted on the head-piece.

25 6. A device as claimed in Claim 5 wherein the carrier element is adjustably mounted on the head-piece.

30 7. A device as claimed in any one of Claims 4 to 6 wherein the carrier element is attached to the head-piece by attachment means comprising two types of pile-bearing fabric, the pile of one of the types of fabric being formed with a plurality of hooks and the pile of the other type of fabric being formed with a plurality of loops in which the hooks are engageable.

35 8. A device as claimed in any one of Claims 4 to 7 wherein the carrier elements are formed at least partly of a flexible foamed material.

9. A device as claimed in Claim 8 wherein the foamed material is a laminate formed of foams of

40 different softness, with the softer foam being provided on the side of the carrier element which is to abut the subject's ear, and the harder, less resilient foam being provided with an aperture for accommodating the emitter.

45 10. A device as claimed in any one of Claims 4 to 9 wherein the head-piece is formed of an elasticated net bandage material.

11. A device as claimed in any preceding claim wherein two emitters are provided, one for each ear of the subject.

12. A device for applying auditory stimuli to the subject, substantially as herein described with reference to the accompanying drawings.

13. A diagnostic apparatus for determining the response of a subject to auditory stimuli, comprising a device according to any preceding claim and a detecting device for detecting the response of the subject.

14. An apparatus as claimed in Claim 13

60 65 70 75 80 wherein the detection device is adapted to detect a change in pulse rate.

15. An apparatus as claimed in Claim 13 or 14, wherein the detecting device is adapted to detect a change in the respiration rate of the subject.

16. An apparatus as claimed in any one of Claims 13 to 15 wherein the detecting device is adapted to detect movement of the subject.

17. An apparatus as claimed in any one of Claims 13 to 16 wherein the detecting device is adapted to detect awakening of the subject.

18. An apparatus as claimed in any one of Claims 13 to 17, wherein the detecting device comprises means for recording the output of the or each sound emitter and the or each response of the subject on parallel traces.

19. An apparatus as claimed in any one of Claims 13 to 18, wherein the or each emitter is an electro-acoustical transducer connected to a recording device to receive therefrom a signal representing a combined uterus sound.

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